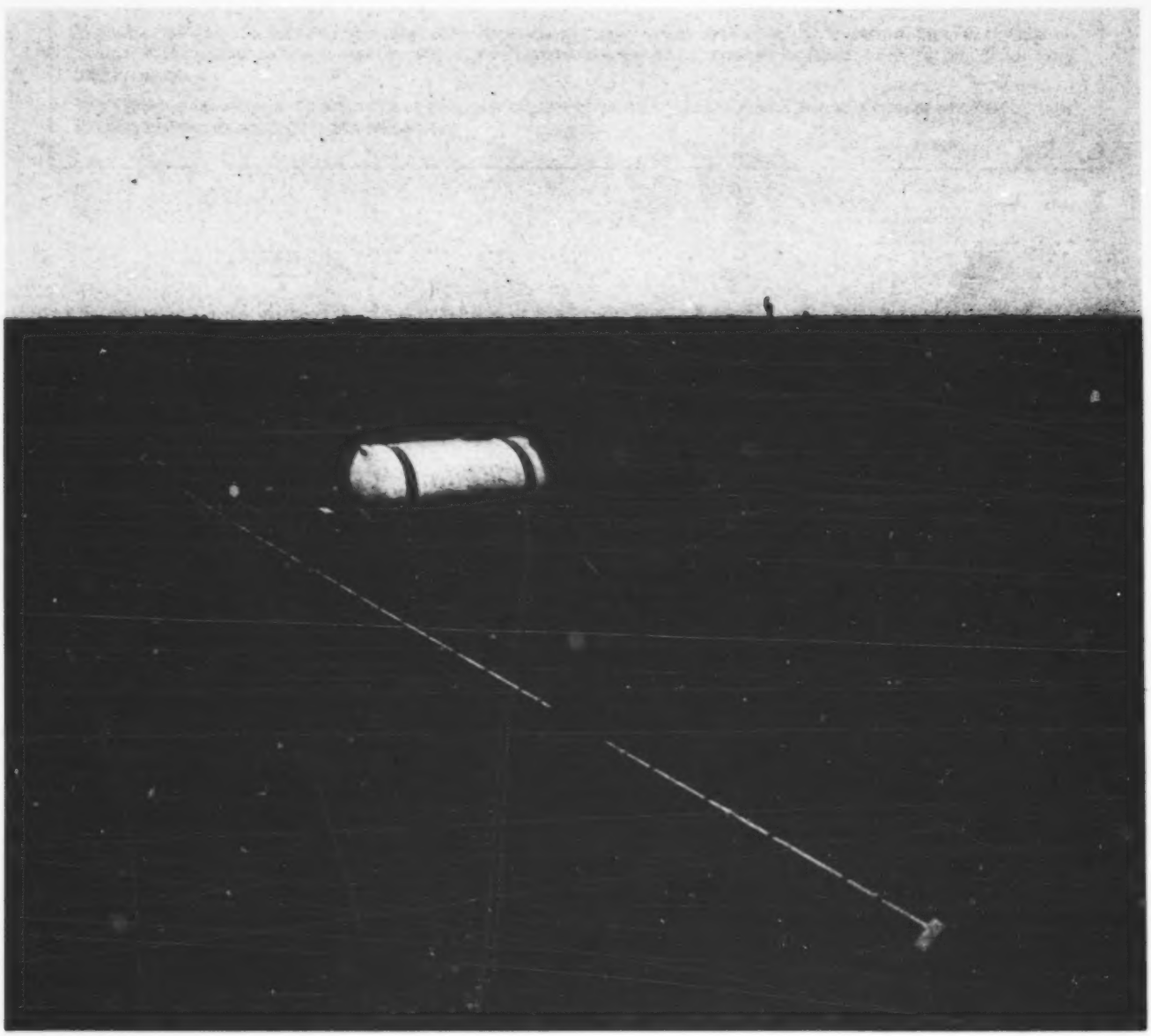
Manitoba
Agriculture

Field Sprayers



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Introduction

The use of modern chemicals demands the best in application equipment. A field sprayer should have the ability to mix and apply a wide range of chemicals accurately and uniformly. Field sprayers should not be selected strictly on the basis of the lowest price since this can result in poor weed and insect control, wasted chemicals and damaged crops. The cost of the chemical applied each year may exceed the price of the sprayer, so taking the risk of inaccurate application by purchasing or using an inadequate sprayer is false economy.

The effectiveness of a spraying operation often depends on proper timing. It is essential, therefore, that the sprayer be designed with efficiency of operation in mind. A minimum of time should be required for filling, cleaning, adjustment and maintenance.

The following component requirements and suggestions are given as a guide for selection and operation of a field sprayer to apply chemicals accurately and efficiently.

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Nozzle Tips

The proper selection and operation of the nozzles on a sprayer is probably the most critical factor in spraying. Several types and many sizes of nozzles are available.

Flat Spray Tips

The most commonly used spray tip for herbicide spraying is the flat spray type. These tips produce a relatively uniform pattern at reasonably low nozzle heights and pressures and are available in many sizes. Table 1 gives the application volumes of some common flat spray tips.

Flat spray tips are available with spray angles of 15°, 25°, 40°, 50°, 65°, 73°, 80°, 95° and 110°. Either 80° or 110° flat spray tips are recommended for herbicide spraying. For a given nozzle spacing, the wider angle tips normally allow a lower nozzle height to be used (see Table 4).

The wider angle tips produce somewhat smaller droplet sizes, which may be an advantage for herbicides or insecticides. Smaller droplets are however more easily carried off target by the wind. The lower nozzle height used with the wider angle tips tends to compensate for the increased drift hazard of the smaller droplets. Lower pressures (200-250 kPa) produce somewhat larger droplets which reduces the amount of spray drift slightly.

Larger nozzle tips usually produce more uniform patterns, have lower wear rates, less variation between nozzles and produce less spray drift due to larger droplet sizes.

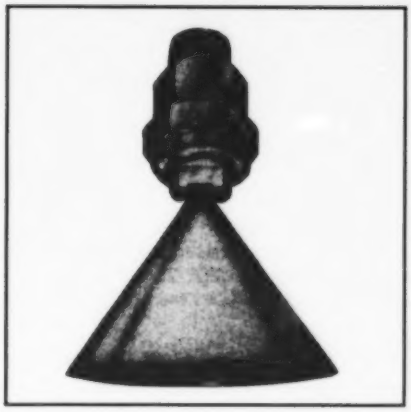
Many different materials are used to make nozzle tips including brass, stainless steel, aluminum, nylon, plastic, ceramics and others. Brass tips are subject to rapid wear and require frequent recalibration (as often as every five hours when wettable powders are used). Their patterns become distorted readily and when this occurs, the nozzle tip must be replaced.

In various controlled wear tests, stainless steel tips have lasted from two to 20 times as long as brass tips. Typically, stainless steel tips will outlast brass tips by more than five to one. Nylon and plastic tips have had equal or better wear life as compared

Table 1. Application Volumes — Flat Spray Nozzles

Nozzle			Pressure	Output	Litres per hectare at 50 cm spacing				
Delavan	Lurmark	Teejet	(kPa)	(L/min)	6 km/h	8 km/h	10 km/h	12 km/h	18 km/h
80° & 110°									
LF1	01-F80	8001	200	0.32	64	48	39	32	21
	01-F110	11001	250	0.36	72	54	43	36	24
			300	0.39	79	59	47	39	26
LF1.5	015-F80	80015	200	0.48	97	72	58	48	32
	015-F110	110015	250	0.54	108	81	65	54	36
			300	0.59	118	89	71	59	39
LF2	02-F80	8002	200	0.65	129	97	77	64	43
	02-F110	11002	250	0.72	144	108	86	72	48
			300	0.79	158	118	95	79	53
LF3	03-F80	8003	200	0.97	193	145	116	97	64
	03-F110	11003	250	1.08	220	162	130	108	72
			300	1.18	237	178	142	118	79
LF4	04-F80	8004	200	1.29	258	193	155	129	86
	04-F110	11004	250	1.44	288	216	173	144	96
			300	1.58	316	237	189	158	105
LF5	05-F80	8005	200	1.61	322	242	193	161	107
	05-F110	11005	250	1.80	360	270	216	180	120
			300	1.97	395	296	237	197	132
LF6	06-F80	8006	200	1.93	387	290	232	193	129
	06-F110	11006	250	2.16	432	324	259	216	144
			300	2.37	474	355	284	237	158

***Note:** Tables of application volumes for other nozzle sizes, spacings and forward speeds are available from the nozzle manufacturers or from Manitoba Agriculture, Engineering Section.*



Flat spray nozzle tip.

to stainless steel in the few tests that have been conducted. Nylon and plastic are however much more easily damaged when cleaning. Even a single insertion of a wooden toothpick can totally ruin the pattern produced by a nylon or plastic tip. Nylon and plastic tips must only be cleaned with compressed air. Additional clean tips should be carried on the sprayer to replace any that get plugged in the field.

Low Pressure (LP) and Extended Range Flat Spray Tips

Low pressure (LP) flat spray tips are intended for operation at pressures of 100 to 275 kPa and have the same outputs at 100 kPa as the standard pressure tips do at 275 kPa. The patterns produced by LP tips are not affected as much by changes in pressure as those produced by standard flat spray tips. Low pressure tips are identified by an LP preceding or following the size number (e.g. LP02-80 or 8002LP). The outputs at various pressures are shown in Table 2.

Extended range flat spray tips are suitable for operation at pressures of 100 to 300 kPa. Their outputs are the same as standard pressure tips, but they maintain a better spray pattern at low pressures. These tips are designated with an LFR (Delavan) or an XR (Teejet). Their application volumes are indicated in Table 3.

Table 2. Application Volumes — Low Pressure Nozzles

Nozzle		Pressure	Output	Litres per hectare at 50 cm spacing				
Lurmark	Teejet	(kPa)	(L/min)	6 km/h	8 km/h	10 km/h	12 km/h	18 km/h
LP01-80	8001LP	100	0.37	74	56	45	37	25
		150	0.46	91	68	55	46	30
		200	0.53	105	79	63	53	35
		250	0.59	118	88	71	59	39
LP015-80	80015LP	100	0.56	112	84	67	56	37
LP015-110	110015LP	150	0.68	137	102	82	68	46
		200	0.79	158	118	95	79	53
		250	0.88	176	132	106	88	59
LP02-80	8002LP	100	0.74	149	112	89	74	50
LP02-110	11002LP	150	0.91	182	137	109	91	61
		200	1.05	210	158	126	105	70
		250	1.18	240	177	141	118	78
LP03-80	8003LP	100	1.12	220	167	134	112	74
LP03-110	11003LP	150	1.37	270	210	164	137	91
		200	1.58	320	240	189	158	105
		250	1.77	350	260	210	176	118
LP04-80	8004LP	100	1.49	300	220	179	149	99
LP04-110	11004LP	150	1.82	360	270	220	182	122
		200	2.11	420	320	250	210	140
		250	2.35	470	350	280	240	157
LP05-80	8005LP	100	1.86	370	280	220	186	124
LP05-110	11005LP	150	2.28	460	340	270	230	152
		200	2.63	530	390	320	260	175
		250	2.94	590	440	350	290	196
LP06-80	8006LP	100	2.23	450	330	270	220	149
LP06-110	11006LP	150	2.74	550	410	330	270	182
		200	3.16	630	470	380	320	210
		250	3.53	710	530	420	350	240

***Note:** Tables of application volumes for other nozzle sizes, spacings and forward speeds are available from the nozzle manufacturer or from Manitoba Agriculture, Engineering Section.*

LP and extended range tips can be used either at low pressure (as low as 100 kPa) to produce relatively large droplets which are less subject to wind effects, or else at higher pressures (up to 300 kPa) for conditions requiring smaller droplets. The low pressure operation is particularly useful for preplant chemicals which do not require small droplets, and which may need to be applied under fairly windy conditions. At the higher pressures, the droplet sizes are quite similar to those produced by standard pressure tips. It is therefore possible to use LP or extended range tips for some post emergence herbicides as well. The herbicide manufacturer should be consulted to check whether these tips are recommended for their product, if there is any doubt.

LP and extended range tips can also be used at spacings greater than 50 cm. With the proper nozzle heights satisfactory coverage can be obtained at spacings up to 100 cm. Nozzle heights should be kept as low as possible to reduce the chances of spray drift, but must be high enough to provide sufficient overlap for uniform coverage.

Low pressure nozzle tip.

Extended range nozzle tips.

Table 3. Application Volumes — Extended Range Nozzles

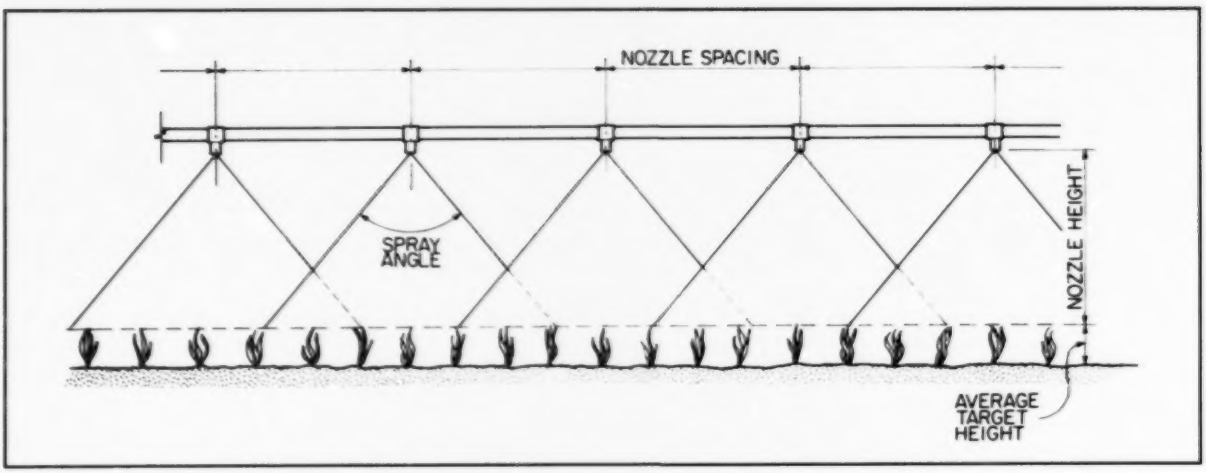
Nozzle		Pressure	Output	Litres per hectare at 50 cm spacing				
Delavan	Teejet	(kPa)	(L/min)	6 km/h	8 km/h	10 km/h	12 km/h	18 km/h
	XR8001	100	0.23	45	34	28	23	15
	XR11001	200	0.32	64	48	39	32	21
		300	0.39	79	59	47	39	26
	XR80015	100	0.34	69	51	41	34	23
	XR110015	200	0.48	97	72	58	48	32
		300	0.59	118	89	71	59	39
LFR2	XR8002	100	0.48	91	69	55	48	31
80°	XR11002	200	0.65	129	97	77	64	43
		300	0.79	158	118	95	79	53
LFR3	XR8003	100	0.69	137	103	82	69	48
80°	XR11003	200	0.97	193	145	116	97	64
		300	1.18	237	178	142	118	79
LFR4	XR8004	100	0.91	183	137	109	91	61
80°	XR11004	200	1.29	258	193	155	129	86
		300	1.58	316	237	189	158	105
LFR5	XR8005	100	1.14	228	171	137	114	76
80°	XR11005	200	1.61	322	242	193	161	107
		300	1.97	395	296	237	197	132
LFR6	XR8006	100	1.37	274	205	164	137	91
80°	XR11006	200	1.93	387	290	232	193	129
		300	2.37	474	355	284	237	158

Nozzle Heights

The recommended nozzle height depends on the nozzle spacing, the spray angle of the tip, the orientation of the nozzle (straight down or 45° ahead) and the pressure. When the nozzles are oriented 45° ahead, the vertical distance from the nozzle to the target should be 75% of the distance shown in Table 4. The recommended heights for straight down orientation of various flat spray tips is given in Table 4.

The diagram below shows the proper method of measuring nozzle height.

Individual calibration of nozzle tips is required to ensure a uniform output along the sprayer boom. Even new nozzle tips may have as much as 10 to 15 percent variation from one to the other. Nozzle calibration cups are available from weed supervisors and agricultural offices. Any nozzle that varies more than five percent from the average or produces a visibly streaked or distorted pattern should be replaced. When the nozzle outputs increase 15% from their original output they should be replaced.



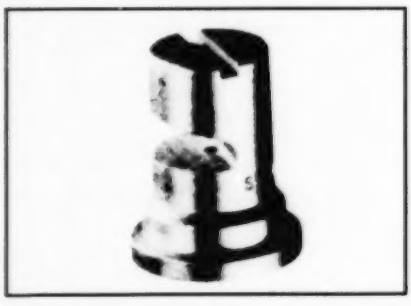
Even Flat Spray Tips

Even flat spray tips are used for band spraying of row crops. They have the same outputs and identification numbers as the standard flat spray tips except that they have an E in the number (e.g. 8002E, E02-F80, or LE2-80°). They are available with 40°, 80°, and 95° spray angles. The edges of the patterns are not tapered as they are with the standard flat spray tips. They provide an even application across their entire width and the patterns are not to be overlapped. The Fact Sheet "Calibration for Band Spraying" Agdex 744 provides information on selection, operation and adjustment of nozzles for band spraying.

Even flat spray tip.

Flooding Tips

Flooding tips are often used for applying liquid fertilizers and are occasionally used for some herbicides. The main advantage of these nozzle tips is that they can be mounted lower than standard flat spray tips and therefore produce less droplet drift at low application volumes (e.g. 40-50 L/ha). In the larger sizes, and at higher operating heights, flooding nozzles show less drift advantage over the flat spray tips. Comparisons of spray drift from various nozzle tips are given in Table 11. Flooding nozzles produce considerably less uniform patterns than flat spray tips and should therefore not be used except when specifically recommended by the herbicide manufacturer. With the new extended range tips available in angles up to 110°, there is little or no reason to use flooding nozzles for any herbicide spraying.



Flooding tip.

Table 4. Nozzle Heights for Flat Spray Tips

50 cm Spacings and 200 - 300 kPa Pressure	
Teejet 8001, 80015, 8002, 8003, 8004 SS Delavan LF1.5-80°, LF2-80° Grey, LF3-80°, LF4-80°, LF5-80° Nylon Computorspray #4 Lurmark 02-F80 Kematal Albuz 80° Yellow, Green Ceramic	45 - 50 cm Above Target
Hardi 4110-12	35 cm Above Target
Delavan LF3.08-73° Nylon	50 or 100 cm Above Target
Cerjet 80° Ceramic	40 - 45 cm Above Target
Lurmark 03-F80 Kematal	55 - 60 cm Above Target
Teejet 11002 SS or Alumax Lurmark 02-F110 SS or Kematal, 03-F110 Kematal Delavan LF2-110° Nylon	45 cm Above Target
50 cm Spacings and 150 - 300 kPa Pressure	
Teejet 8001LP, 80015LP, 8002LP ,8003LP, 8004LP SS	40 cm Above Target
Lurmark LP015-80, LP02-80, LP015-110, LP02-110 Kematal	45 cm Above Target
50 cm Spacings and 100 - 300 kPa Pressure	
Teejet 11002LP SS	25 cm Above Target
XR11001, XR110015, XR11002 SS	25 - 35 cm Above Target
Lurmark LP03-80, LP04-80 Kematal	50 cm Above Target
LP03-110, LP04-110 Kematal	45 cm Above Target
75 cm Spacings and 200 - 300 kPa Pressure	
Teejet 11002, 11003 SS	35 - 40 or 60 cm Above Target
75 cm Spacings and 100 - 300 kPa Pressure	
Teejet 11002LP, 11003LP SS	40 or 60 cm Above Target

Not Recommended For Use

Sprajet 65.067 Brass	Computorspray #2 & #3
Teejet 650067 Brass	Albuz 80° & 110° Orange
Delavan LF1-80° Nylon	Albuz 80° Red
Lurmark 01-F80, 015-F80, LP01-80 Kematal, 02-F80 SS	

Caution: *Nozzle pressures above 300 kPa are not recommended for herbicide spraying because of the increased danger of spray drift.*

Laboratory tests have shown that a nozzle height of about 40 cm produces the best pattern with flooding nozzles at 275 kPa pressure and 100 cm spacing, when spraying straight down. When spraying 45° ahead, a height of about 25 to 30 cm is best. It should be noted that even under ideal conditions the patterns produced by flooding nozzles are very uneven and may be too variable for good weed control and crop safety. Operating at lower pressures normally makes the patterns somewhat more uneven.

Positioning flooding nozzles to direct the spray straight back may improve the uniformity of application but will also greatly increase the drift hazard. Unless otherwise specified by the herbicide manufacturer, flooding nozzles should be positioned to spray straight down.

Note: *Flat spray tips of the appropriate size and type will normally produce a better combination of pattern uniformity and drift control than will flooding nozzles.*

The application volumes of several common flooding nozzles are shown in Table 5.

Table 5. Application Volumes — Flooding Nozzles

Nozzle			Litres per hectare at 100 cm spacing (275 kPa pressure)			
Delavan	Lurmark	Spraying Systems	6 km/h	8 km/h	10 km/h	20 km/h
D 1	AN 1	TK 1	76	57	46	23
D 1.5	AN 1.5	TK 1.5	113	85	68	34
D 2	AN 2	TK 2	151	113	90	45
D 2.5	AN 2.5	TK 2.5	190	142	114	57
D 3	AN 3	TK 3	226	170	136	68
D 4	AN 4	TK 4	306	229	183	92
D 5	AN 5	TK 5	378	284	228	114

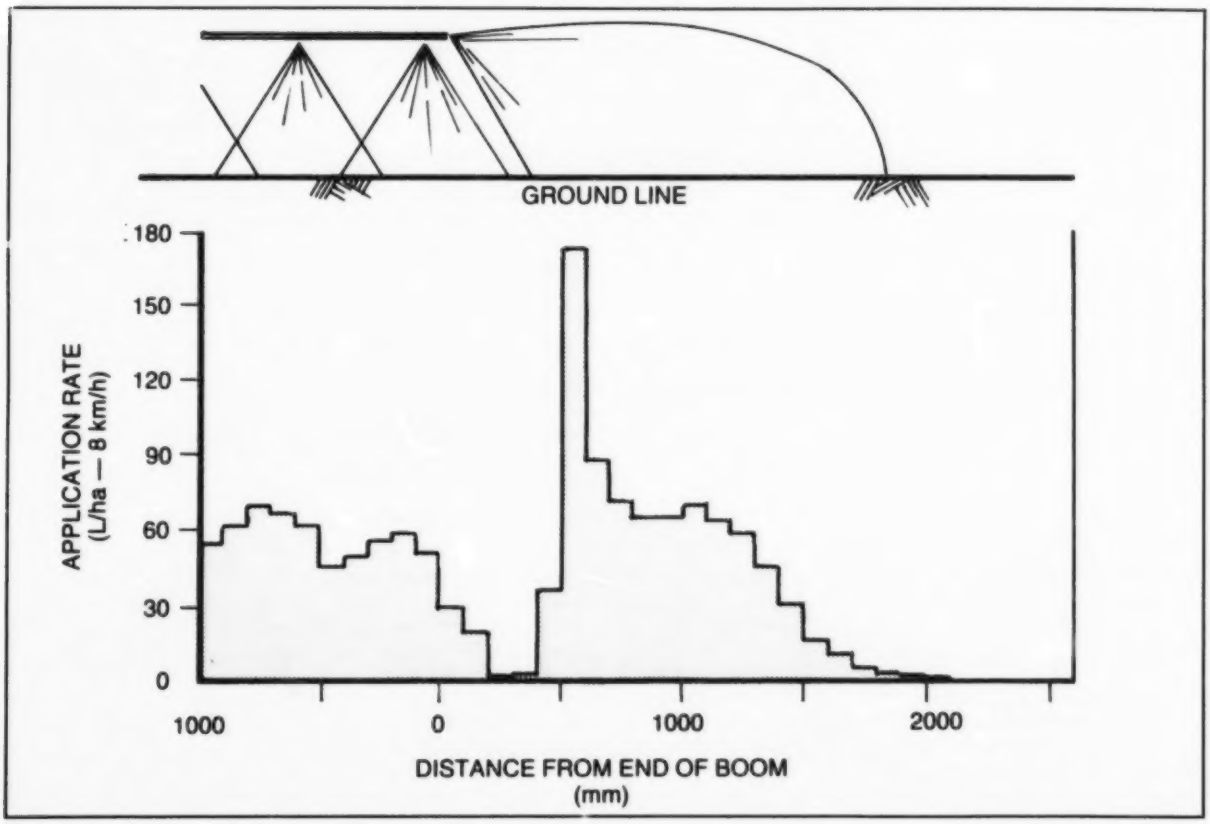
Cone Spray Tips

There are a number of nozzle tips that produce cone shaped spray patterns. These are primarily used for insecticides and fungicides, and for aerial applications. Some types (e.g. Raindrop nozzle) produce larger droplet sizes which are very resistant to spray drift when used with low nozzle heights and directed to spray straight down. However, both the Raindrop and the Whirlchamber nozzles produce very uneven patterns when directed straight down. Turning the nozzles to direct the spray straight back improves the patterns substantially but also increases the drift potential. For most herbicide spraying it is therefore recommended to use appropriate flat spray tips since they produce a better combination of pattern uniformity and drift control than do cone spray tips.

End Nozzles

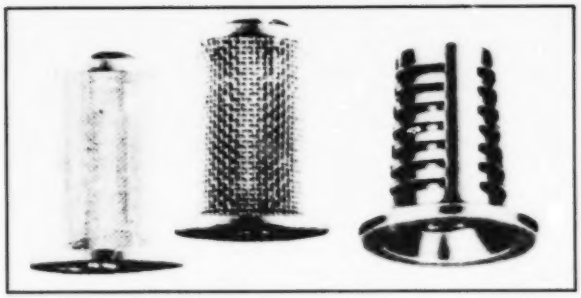
End nozzles with off-centre spray tips produce a very uneven spray pattern, and direct much of the spray horizontally which makes it very susceptible to spray drift. They frequently produce gaps in coverage at the end of the boom and/or very high application volumes near the end of the boom. These nozzles should therefore not be used for general field spraying. They should only be used for areas that are inaccessible to the spray boom (fence rows, ditches, etc.) and only when winds are very light.

Below: Typical variation in application rate when using an end nozzle. (Illustration)



Nozzle Screens

The most desirable location for nozzle screens is inside the boom so that the passing liquid prevents foreign material from accumulating on the screens. The foreign material then collects at the end of the boom where it can be easily flushed out. Proper filter maintenance, thorough tank cleaning and the use of clean water will prevent most plugging problems. For wettable powders, a 50 mesh screen or a slotted strainer should be used. For liquid herbicides, the nozzle manufacturer's recommendations should be followed to select the appropriate mesh of screen for a particular tip size.



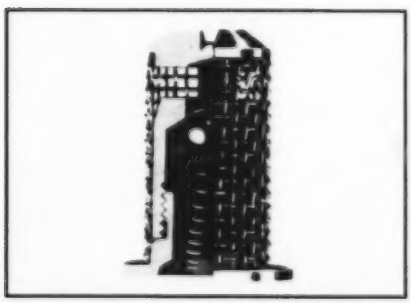
Nozzle screens and strainer.

Check Valves

Nozzle check valves are used to prevent nozzle dribble when the pressure is shut off, and sputtering when the pressure is reapplied.

Ball Check Valves

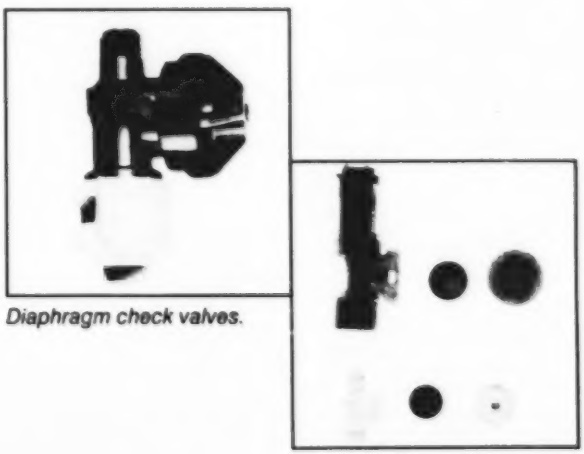
Spring loaded ball check valves with a 35 kPa spring are most common but 70, 140 and 280 kPa springs are also available. The liquid pressure in the boom must be increased by the amount of the spring pressure to overcome the extra resistance. For example if the desired nozzle pressure is 250 kPa and the ball check valves are equipped with 35 kPa springs, the boom pressure must be set at 285 kPa. Some makes of ball check valves have very large pressure differences from one to another and should therefore not be used. Contact your local agricultural engineer for details on individual makes and models. Certain chemicals such as Treflan and other wettable powders may cause sticking of the check valves. Frequent thorough cleaning with a detergent solution helps to reduce this problem.



Ball check valve.

Diaphragm Check Valves

Diaphragm check valves have several advantages over ball check valves. They are less prone to sticking and erratic behavior, and they have no measurable pressure drop when operated within their recommended flow rates. The commonly available diaphragm check valves show no pressure drops at flow rates below 3 L/min. Some models have no pressure drop up to 5 or 7 L/min. Valve opening pressures are typically about 50-60 kPa, but once the valve is opened, there is no measurable flow restriction at the flow rates given above. The boom pressure should therefore **not** be increased when using diaphragm check valves as it is when using ball check valves. If nozzles with outputs above 3 L/min are used the pressure drop across the check valve should be measured, and the boom pressure adjusted accordingly.



Diaphragm check valves.

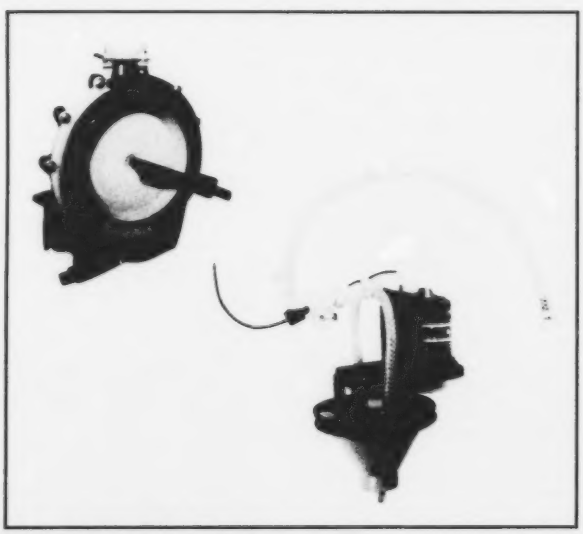
Controlled Droplet Applicators

Hydraulic nozzles use liquid pressure to meter out the spray solution, form the droplets and develop a spray pattern. A different type of spray distributor called the controlled droplet applicator uses centrifugal force to break the liquid into droplets and distribute them in a circular pattern. Several different types of controlled droplet applicators (CDA) are available, some with horizontal spinners and some with vertical spinners. The range of droplet sizes produced by these applicators is much narrower than that produced by hydraulic nozzles. The size of the droplets can be varied by changing the rotational speed of the disc or cone and by changing the amount of liquid being fed into the applicator. Some applicators have only two speeds (2000 and 5000 rev/min) while others are infinitely variable up to 7000 rev/min. Typical droplet sizes produced vary from 75 micrometres (μm) for insecticides and fungicides to 325 μm for herbicides. Typical application volumes vary from 20 to 50 L/ha depending on forward speed, spacing and liquid flow rate to the applicators. The flow rate is usually controlled by means of metering orifices and the pressure in the supply lines.

The primary advantages of the CDA are the uniformity of droplet sizes produced and the possibility of using lower water volumes as compared to hydraulic nozzles. Large droplets (over 350 μm) have a tendency to run off the plants, and small droplets (less than 100 μm) are very subject to wind drift. By producing a higher percentage of droplets within the 200-300 μm range, there should be less wastage of chemical and less environmental hazard. The resulting reduction of water volume needed for good coverage is also an attractive feature for most farms.

Most of the work on CDA's conducted in North America has been done with the Micromax unit. This CDA uses a horizontal cone shaped spinner. Some trials have shown substantial reductions in spray drift while others have indicated more spray drift as compared to hydraulic nozzles, depending on the rotational speed and the resulting droplet size. Weed control comparisons have also been variable. In most cases the weed control achieved has been similar to that obtained with hydraulic nozzles and in some cases it has been poorer. No reduction in chemical rates is recommended when using CDA's. Using water volumes lower than those specified on the pesticide label may increase crop damage and reduce weed control. Herbicide warranties do not apply to applications made with water volumes lower than those given on the label.

The uniformity of application is slightly less with the Micromax than with a good flat spray tip. (CV of 14-17% as compared to 5-10%). To obtain the best possible uniformity with the Micromax, the units must be spaced at 2.0 to 2.1 m on a pull type sprayer. For higher speed self-propelled sprayers, a closer spacing may be required. The applicators should be located at 33 to 60 cm above target. Flow rates must be between 1.0 and 3.5 L/min. The higher flow rates produce larger and less uniform droplet sizes. The applicator units must not be tilted to either side, although tilting them forward slightly doesn't affect the pattern. The unit must be mounted below or at least 1.2 m away from all other parts of the sprayer. This presents major modification problems for most pull type ground sprayers. Indications are that sprayers specially designed for CDA's are needed to obtain satisfactory field performance.



Controlled droplet applicators.

Booms

Sprayer booms must be horizontally and vertically stable to allow the nozzles to produce an even distribution of chemicals. Boom carrier wheels are required to maintain the boom at a uniform height above the ground. Shock mounted boom wheels or tandem boom wheels with low pressure tires are recommended to provide a smooth ride. On large sprayers (over 20 m) multiple section booms are desirable since they follow the ground variations more closely than single section booms.

The boom height should be adjustable to allow a nozzle height range of 20 to 80 cm above the ground. The boom should also be adjustable to allow spraying at a 45° forward angle without having the spray hit the boom wheels or frame. These adjustments should be able to be made with a minimum of time and effort.

Pumps

Selection of the proper pump size is important to ensure sufficient pressure at the nozzles, adequate agitation, and allowance for wear. Table 6 gives the recommended pump outputs for various sizes of sprayers. For other forward speeds or application volumes, the required pump output can be calculated from the following formula:

pump output (L/min) =

$$\frac{\text{sprayer width (m) x forward speed (km/h) x application volume (L/ha)}}{480} + \text{sprayer width (m)} \times 1.5$$

Example: *25 m sprayer, speed 15 km/h, application volume 150 L/ha.*

Required pump output =

$$\frac{25 \times 15 \times 150}{480} + 25 \times 1.5 = 117 + 38 = 155 \text{ L/min}$$

The capacities given in Table 6 include a wear allowance of 25 percent and about 1.5 percent of the tank capacity per minute for agitation. If wettable powders are to be used an extra 40 to 50% should be added to the pump capacity. If the output drops to less than 80% of the capacities given, the pump should be overhauled or replaced.

The capacity of a sprayer pump can be checked as follows:

1. Direct the total pump output into a container of known volume (e.g. 200 litre drum). With a roller pump system this is most easily done by shutting off the boom lines and agitator line, disconnecting the bypass line and directing it into the container.
2. Using the desired PTO speed and operating pressure, determine the time needed to fill the container.
3. Divide the number of litres collected by the minutes required to fill the container.

Table 6. Pump Capacity Requirements (litres per minute)

Width of Sprayer (m)	Ground speed 10 km/h		Ground speed 20 km/h	
	Application Volume			
	50 L/ha	100 L/ha	50 L/ha	100 L/ha
12	31	43	43	68
14	36	50	50	79
16	41	57	57	91
18	46	65	65	102
20	51	72	72	113
22	56	79	79	125
24	61	86	86	136
26	66	93	93	147
28	71	100	100	158
30	76	108	108	170
32	81	115	115	181
34	86	122	122	193
36	92	129	129	204
38	97	136	136	215
40	102	143	143	227

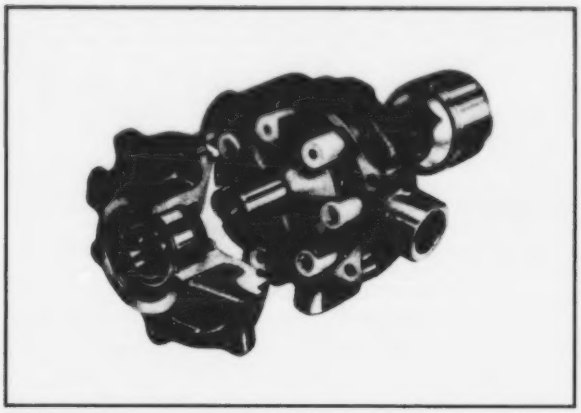
Roller Pumps

Table 7 gives the capacities of some common roller pumps when operating at a pressure of 350 kPa.

Table 7. Roller Pump Capacities

Pump	Output at 540 rev/min	Maximum rev/min	Output at max rev/min
	L/min		L/min
Delavan 55-5110	79	1000	162
66-5110	32	1000	67
77-5100 & 6100 series	50	850	80
88-5100 & 6100 series	43	1000	85
General G-8C	46	600	51
Hypro 6500	28	1200	68
7560	42	1000	83
7700	47	800	78
1700	77	600	87
1500	103	800	166
1200	184	800	274
1100	258	600	294

Note: *When increasing the size of pump or increasing pump speed, be sure to increase the hose sizes as shown in Table 9.*



Roller pump.

Rollers are available in nylon, polypropylene, Teflon and rubber. Rubber rollers have a longer service life than nylon or polypropylene rollers if used for pumping large quantities of plain water or abrasive powders in suspension. Some pumps require the rotor edges to be rounded before installing rubber rollers. Do not exceed 700 kPa when using rubber rollers.

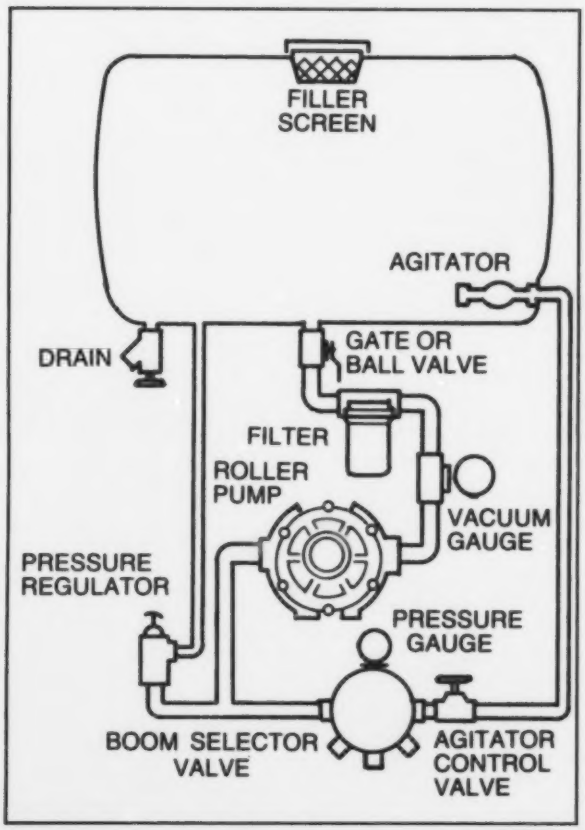
The service life of a roller pump depends on the care and maintenance it receives. With careful maintenance and the use of clean water, a pump can last for several hundred hours. For maximum life, the pump should be flushed out with anti-freeze solution if left idle for more than a day. Pumping water with soil or other abrasives in it can reduce the pump output by as much as 30% in 50 hours. Other common causes for short pump life are leaving water in the pump during freezing weather or having too much restriction in the suction line which creates cavitation in the pump. Tapered rollers are an indication of too much restriction in the inlet line.

The use of pumps with Ni-Resist bodies is recommended. This material, although higher in price than cast iron, resists rusting and corrosion much better, thereby extending roller and pump life substantially.

A proper circuit diagram for a sprayer with a roller pump is shown below.

To adjust this system properly: (1) Close the agitator line control valve and open the boom selector valve (or spray gun). (2) Start the sprayer, make sure flow is uniform from all spray nozzles, and adjust the pressure regulator until the pressure gauge registers about 75 to 100 kPa above the desired spraying pressure. (3) Slowly open the agitator control valve until spraying pressure is reduced to the desired value. If the pressure will not come down to the desired value, even with the control valve wide open, replace the agitator nozzle with one having a larger orifice.

If insufficient agitation results when spraying pressure is correct and the pressure regulator is closed, try a smaller agitator nozzle. This will increase agitation and permit a wider open control valve for the same pressure.



Plumbing diagram for roller pump.

Centrifugal Pumps

Centrifugal pumps are also commonly used for field sprayers. They are not as susceptible to wear from foreign particles in the water as are roller pumps. They are fairly easy to maintain and usually have high capacities. The pressure output can be controlled by a simple shutoff valve rather than a pressure regulating valve. They require very high rotational speeds (over 3000 rev/min) so are usually driven with a step-up gear or belt drive or a hydraulic motor. They are not capable of producing high pressures (maximum is usually 350 to 400 kPa) and the output drops off rapidly above 300 kPa. They require a positive inlet pressure for priming and are subject to vapor locks, particularly if a positive vent line is not used.

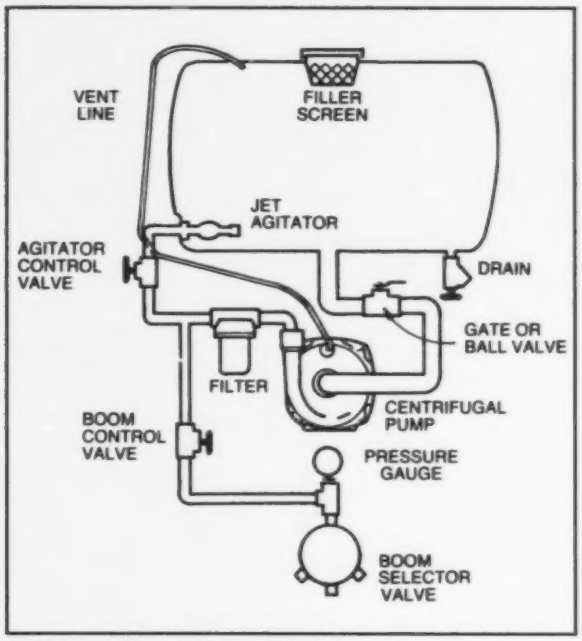
Turbine pumps have similar characteristics to centrifugal pumps. They can however, be run by direct drive from a 1000 rev/min power take off or with a step-up drive from a 540 rev/min shaft. These pumps are also well suited to pumping abrasive wettable powder solutions.

The outputs of some of the common centrifugal and turbine pumps are shown in Table 8.

The output of a centrifugal or turbine pump is very dependent on the speed of rotation. Operating at lower than rated speed will produce much lower outputs than those given in Table 8. Even a small drop in speed will lower the output drastically. This will lower the pressure produced and cause deterioration of the spray pattern with most nozzles. Operating at higher than recommended speeds may reduce pump life substantially.

Large hoses and fittings must be provided for a centrifugal pump. Typical suction hose sizes are 32 to 50 mm inside diameter. Normally the suction line is one size larger than the outlet.

Caution: *Before selecting a hydraulic motor driven pump make sure that the tractor hydraulic system is designed for operating hydraulic motors. Many of the older tractors and some new ones have insufficient cooling capacity for the heat produced by a hydraulic motor. Severe damage to the tractor's hydraulic system can result if the oil gets too hot. When selecting a hydraulic motor be sure that it is compatible with the tractor hydraulic system, i.e. pressure, flow rate and open or closed centre. Some motors may be adjusted for flow rate and for open or closed centre hydraulic systems. Be sure to read and follow all the manufacturer's instructions for installation, adjustment and operation of the hydraulic motor and pump.*



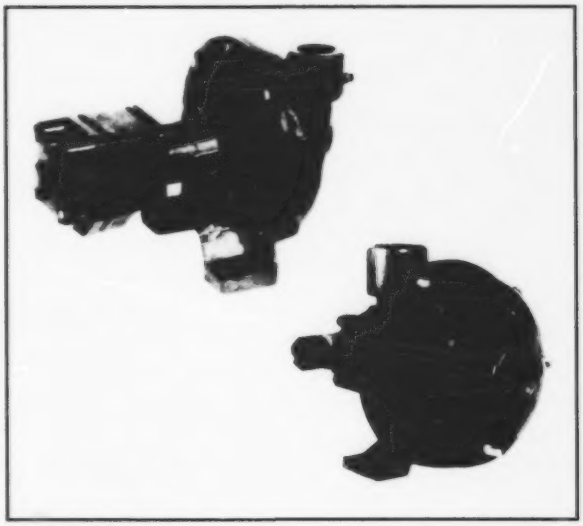
Plumbing diagram for centrifugal pump.

A proper circuit diagram for a sprayer using a centrifugal pump is given below.

To adjust the system that uses a centrifugal pump:

1. Close the boom control valve and the agitator valve; open the boom selector valve.
2. With the pump running, open the boom control valve until the pressure gauge indicates the desired spraying pressure.
3. Open the agitator valve until sufficient agitation is observed. Then, if agitation flow has lowered the pressure, readjust the boom control valve to restore the desired pressure. Make sure flow is uniform from all nozzles.

A pressure regulator valve should not be used with a centrifugal pump. It causes the pump to produce more flow, thereby reducing its life and possibly causing overheating of the oil on a hydraulically driven pump.



Centrifugal pumps.

Table 8. Centrifugal Pump Capacities

Pump	rev/min	200 kPa L/min	300 kPa L/min
Ace FMC-HYD-204, 210 & 310	4600	230	190
Ace FMC-200-HYD-210 & 310	3950	475	250
Ace FMCH-HYD-210 & 310		230	225
Delavan Turbo 90	1000	174	112
Delavan 34945-1		169	132
Delavan 35566-1		206	168
Delavan 46818-1		230	195
Hypro C9006	540 (impeller @ 3780)	365	305
Hypro C9008	1000 (impeller @ 4000)	390	350
Hypro 9202C	3600	255	210
Hypro 9203C	3600	370	305

Hoses and Fittings

Large capacity pumps will not provide satisfactory performance if the hoses and fittings are undersized. Minimum hose and fitting sizes for centrifugal pumps are specified by the manufacturers. The **minimum** recommended hose and fitting sizes for roller pumps are listed in Table 9.

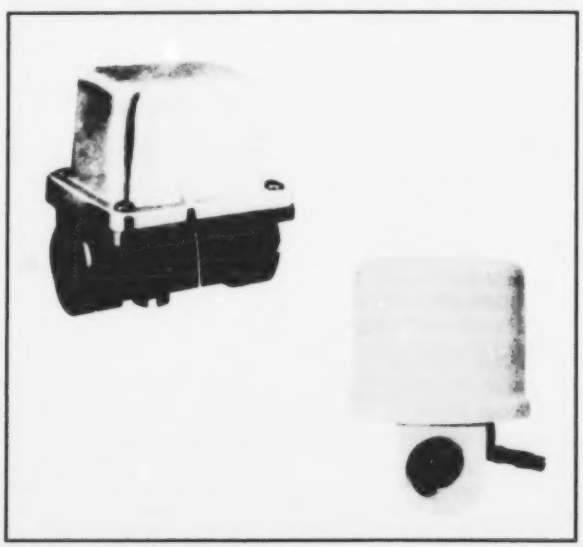
All hoses should be able to withstand at least 1400 kPa pressure. Open globe valves cause about 50 times as much flow restriction as open gate valves of the same size, so they should only be used where throttling (pressure reduction) is required. Gate valves and ball valves have full size, straight through openings, thus causing very little restriction when fully open.

Table 9. Recommended Hose and Fitting Sizes

Pump Capacity (L/min)	Suction Line (mm)	Agitator Line and Boom Lines (mm)	Pressure Line Pressure Regulator and Bypass Line (mm)
30	20	12	12
50	25	12	20
80	32	20	25
120	32	20	32
200	40	32	40
300	50	40	50

Pressure Gauges

The pressure gauge should read from 0 to 500 or 700 kPa and be easily visible from the tractor seat. Gauges that go beyond 700 kPa are usually difficult to read accurately. For hand gun operation a higher range pressure gauge may be required. A spare gauge should be kept on hand at all times, so that if the one on the sprayer begins to malfunction a new one can be installed immediately. This spare gauge can also be used to check for pressure drops in the system by installing it temporarily at the end of the boom and comparing the reading with that on the other gauge. This check should be made whenever larger nozzles are installed or any malfunction is suspected. A gauge damper makes it easier to read the gauge accurately and also prolongs the life of the gauge. Ideally, pressure readings should be taken at the boom rather than at the control valve. Remember to increase the boom pressure by the appropriate amount if ball check valves are being used at the nozzles.



Electric pressure regulators.

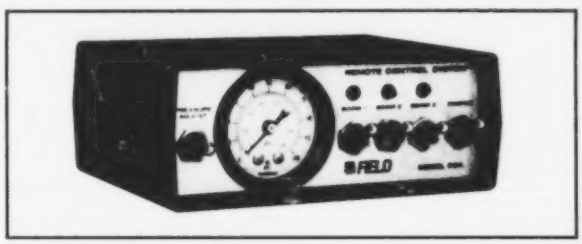
Monitors and Controls

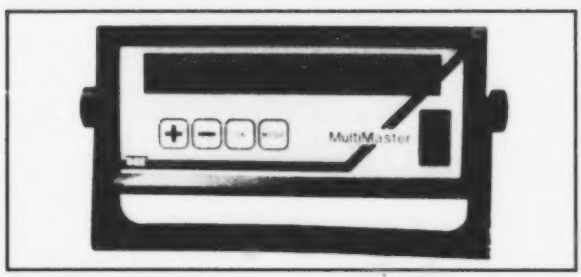
All operating controls should be easily accessible from the tractor seat. Solenoid operated shutoff valves and electrically operated pressure regulators can be used for remote operation. These items are particularly desirable when a cab equipped tractor is used for spraying. Monitors giving continuous application rate readings in litres per hectare are also available. Careful calibration and proper maintenance of these units is essential to ensure reliable readings. Some of these monitors also read out pressure, forward speed, litres used, hectares covered, litres per minute, hectares per hour, and total distance travelled. Various controllers are also available to maintain a constant application rate with changes in forward speed. These units automatically adjust the boom pressure to compensate for speed changes. Care must be taken to keep the nozzle pressure within the recommended limits to avoid uneven patterns from low pressures, and drift hazards from high pressures. There are also monitors available which indicate when a nozzle is plugged. All of these devices can be helpful in doing a more accurate spraying job, with a minimum of inconvenience.

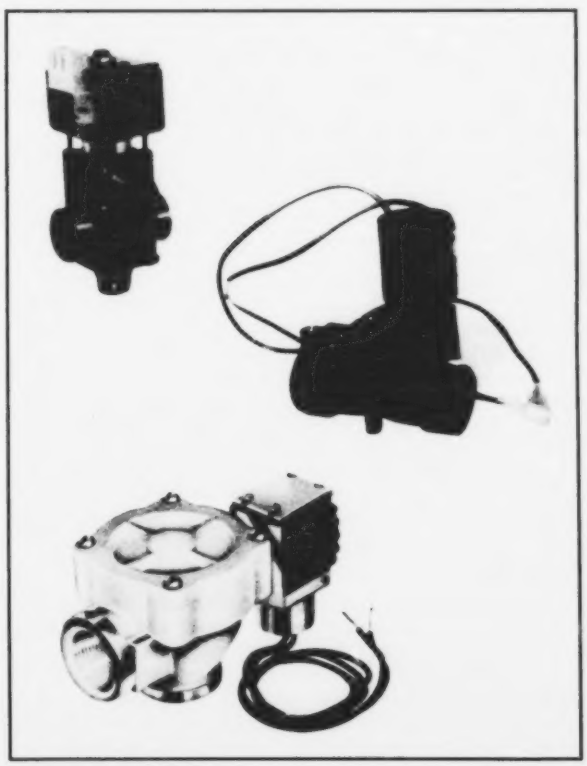
A vacuum gauge in the suction line just ahead of the roller pump can be used to indicate when the filter needs cleaning, or if there is any obstruction in the suction line. A maximum vacuum of 35 kPa is permissible for roller pumps.

Caution: *Hoses carrying chemicals should not be located in an operator's enclosure.*

Below left and below: sprayer monitors and controls.





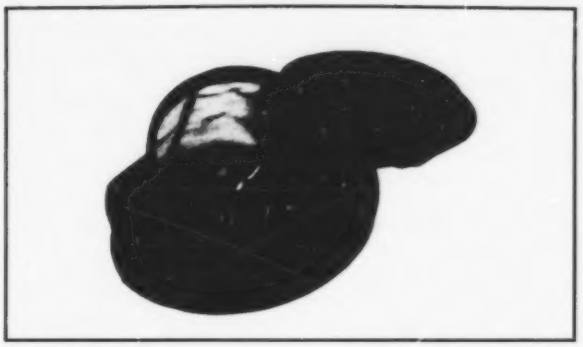


Electric shut-off valves.

Filters and Screens

A screen or filter should be located on the inlet side of a roller pump to prevent dirt from entering the pump. A large screen with inlet and outlet fittings of the same size as the suction hose should be used to keep the pressure drop as low as possible. A 60 mesh screen is satisfactory for most chemicals other than wettable powders which require a 40 or 50 mesh screen. Felt filters should not be used since they plug up when using wettable powders, they create high flow restrictions, cannot be cleaned properly, and disintegrate with use causing poor filtering and nozzle plugging.

A large area fine mesh (80 or 100 mesh) screen should be located in the tank filler hole to filter all the water entering the sprayer tank. If the sprayer is cleaned originally and no foreign material is allowed to enter the system there should be very few problems with plugged screens or nozzles.



Tank filler screen.

Tanks

A variety of materials are used for making sprayer tanks, the most common being galvanized steel, aluminum, polyethylene and fibreglass. Galvanized steel and aluminum have provided satisfactory service for many years, although some scaling and rusting may occur in galvanized tanks, and some chemical reaction between aluminum and TCA has been observed in lab tests. The best way to prevent the above problems is to clean the tanks promptly and thoroughly after every use. The herbicide Roundup and liquid nitrogen fertilizer cause a potentially hazardous reaction with galvanized steel, so these chemicals should not be placed into a galvanized tank.

Polyethylene and fibreglass tanks appear to be resistant to attack from all commonly used farm chemicals and are usually easy to keep clean. There are wide variations under the general term of "poly" tanks due to substantial differences in materials, design and quality control between manufacturers. Some types of polyethylene are much more resistant than others to deterioration by sunlight, some are more durable in cold weather and some absorb much less chemical than others. Some types may be repaired with special equipment while others must be replaced if damaged. Fibreglass tanks may also vary a great deal in design and workmanship. With either poly or fibreglass, reputable suppliers who will guarantee their products should be a prime consideration. The terms of the guarantee and replacement policy should be fully understood by the purchaser.

Fibreglass tanks must be protected from sharp impact loads, but if punctured they can be repaired quite easily. Polyethylene tanks should be protected from sunlight when not in use, to extend their service life. Proper mounting and securing is of critical importance with polyethylene and fibreglass tanks. An adequate saddle is needed to prevent high stress areas on the tank, and firm restraint must be provided to prevent bouncing or rubbing between the tank and other parts of the machine. Manufacturer's mounting instructions should be followed explicitly. Prompt cleaning of the tanks after use, and protection from animals or other equipment is recommended.

A large, properly located drain hole is essential for fast and thorough cleaning of the tank. The location of the drain hole should allow all the liquid to drain out easily. A centre drain in a flat bottom tank is very inconvenient and seldom allows all the liquid to drain out. The drain on a flat bottom tank should be located at one corner of the tank bottom.

Filler openings should be large enough to allow easy filling and good visibility for cleaning and inspection of the tank. A 30 to 40 cm diameter hole is sufficient. This size allows a large screen to be placed in the filler opening to permit fast filling and adequate filtering. An 80 or 100 mesh screen is recommended. A leakproof lid should be provided to prevent waste of chemical and to keep the outside of the tank clean. The filler hole should be located to permit convenient access for adding water and pouring chemicals into the tank. A safe convenient platform to stand upon while pouring chemicals should be provided, unless the filler hole can be reached while standing on the ground.

Caution: *Do not enter a tank that has had chemicals in it. Large filler holes should be provided with sufficient restrictions to prevent children from entering the tank.*

Field efficiency is increased with the use of larger tanks. The extra weight will cause more compaction but the effects can be minimized by using larger tires and/or tandem wheels. Sprayer wheels should follow the tractor tracks to keep crop losses and compaction to a minimum.

Tanks should have permanent capacity markings and a liquid level gauge that is not affected by tank slope.

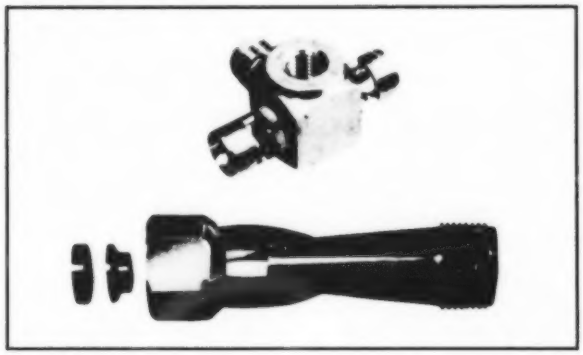
Agitators

Intense agitation is required to keep some chemicals in suspension. The return flow from the pressure regulator does not normally provide enough agitation, especially if the pump output drops off. To ensure adequate agitation for all chemicals, a mechanical or jet agitator should be used in the tank. A jet agitator is easier to install in most existing sprayers, although mechanical agitators provide the most positive mixing.

Jet agitators with venturi caps have an output of two or three times their input. Various types and sizes are available for different sizes and shapes of tanks. The input per minute to the agitator should be about one to two percent of the tank volume for liquid chemicals, and three to four percent for powders. In order to get adequate mixing of wettable powders, several nozzles are required to get a complete sweep of the tank bottom. Large flat bottom tanks need several nozzles or a multidirectional jet agitator to achieve adequate mixing. Sparge tubes can also provide good mixing especially in cylindrical tanks, provided they run the full length of the tank. Jet agitators must **never** be connected to the return line from the pressure regulator. They must be operated from a separate pressure line.

Jet agitators must be securely fastened inside the tank to prevent whipping. A throttling valve should be provided in the agitator line to reduce the flow if excess foaming occurs.

The inputs of some common agitator nozzles are given in Table 10.



Jet agitators.

Table 10. Jet Agitator Capacities

Nozzle	Orifice Size or Number	Input at 275 kPa (L/min)
Delavan 25467		57
36743	3.2 mm	13
	4.0 mm	18
	4.8 mm	23
	6.3 mm	28
Hypro 3371	3.2 mm	9
	4.0 mm	14
	4.8 mm	19
Hypro 3371-19	3.2 mm	12
	4.0 mm	18
	4.8 mm	24
Spraying Systems		
6290-SC Series	1	6
	2	14
	3	18
	5	34
	8	39
	10	43

Spray Drift

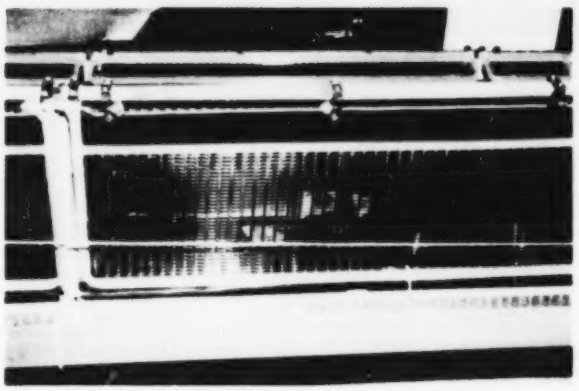
Spray drift is one of the most serious problems in chemical application. The small particle sizes required for efficient weed or insect control, and practical limitations on the amount of water carried, present a potentially hazardous situation wherever chemicals are used. Selecting equipment, application volumes, chemicals, atmospheric and field conditions that will minimize spray drift is the responsibility of everyone who applies pesticides.

Factors that will reduce spray drift hazards are:

- Use of large droplet sizes.
- Spraying when wind speeds are low and blowing away from sensitive crops, gardens, shelterbelts, etc.
- Use of sprayers with a low nozzle height, with the spray being directed straight down or at a slight angle from vertical.
- Use of low or nonvolatile chemicals.

Droplet size is affected by several factors. High pressures and small nozzle tips create small droplets. These together with high air temperatures, low relative humidity, high wind speeds and high boom heights, are the most common causes of excessive spray drift. Selecting suitable weather conditions for spraying is extremely important. The winds are likely to be lowest between 10 p.m. and 7 a.m. and the relative humidity is normally highest early in the morning. The least hazardous time for spray drift is therefore usually before 7 a.m. When there is no wind at all it is hazardous to spray near sensitive plants since a suspended cloud of chemical may be carried towards the sensitive area when the wind starts up. It should be noted that certain herbicides must not be applied when the plants are wet, so early morning hours are not always suitable for these chemicals.

Selection of nozzles and nozzle heights is extremely important in controlling spray drift. In field tests with wind speeds of 20 km/h, relative drift potentials were observed with various nozzles. They are listed in the following table.



Above and below: wind screens.

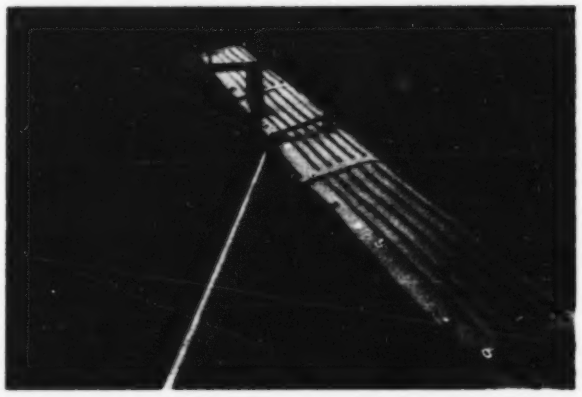


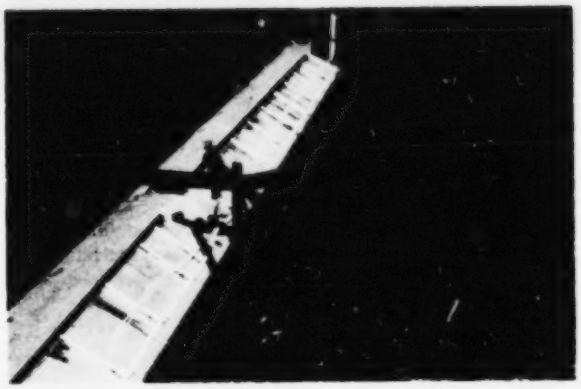
Table 11. Nozzle Drift Potential

Nozzle	Nozzle Height (cm)	Nozzle Pressure (kPa)	Relative Drift Potential
8002 LP	46	100	1
8002	46	210	2
RD-1 (horizontal)	36	210	2
TK.75	33	275	3
650067	56	275	8
730077	100	275	20

Under the conditions indicated above the 730077 nozzle produced 20 times as much drift as the 8002 LP and 10 times as much as the 8002. It should be noted that certain herbicides require small droplet sizes in order to be effective. Be sure to read the herbicide manufacturer's recommendations on nozzle sizes and pressures. The five bottom pictures on the opposite page (19) illustrate the relative droplet size and target deposit uniformity of several common nozzle tips.

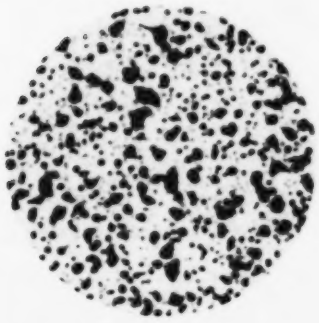
General guidelines for application of herbicides with field sprayers are:

- Do not spray in winds above 20 km/h.
- Do not use nozzle pressures above 300 kPa.
- Use a minimum of 100 L/ha of water for all herbicides except where otherwise specified on the label.
- Use a nozzle height of 50 cm or less above target.
- Do not spray when the wind is blowing towards a nearby sensitive crop, shelterbelt or garden.
- Do not spray in a dead calm near sensitive plants.
- Do not use end nozzles for field spraying. Use them only for areas inaccessible to the spray boom, and only when winds are very light.
- Select nozzles that will produce uniform patterns, correct application rates and low drift hazards. For most conditions, 80° or 110° flat spray nozzles produce a better combination of pattern uniformity and drift control than do flooding nozzles, 65° or 73° flat spray nozzles, or cone spray nozzles.

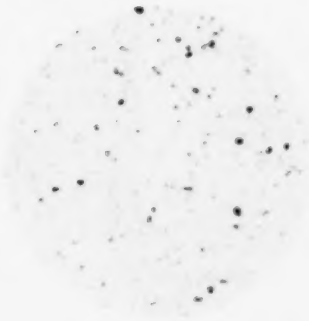


Wind screen.

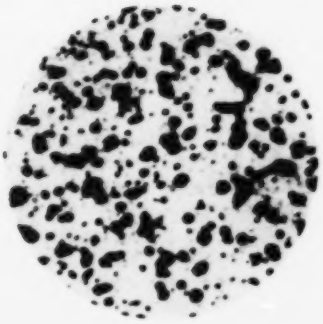
Spray Patterns



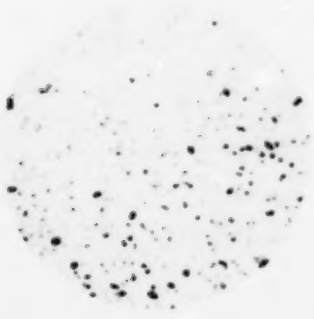
Spray pattern of 8002 tip @ 210 kPa.



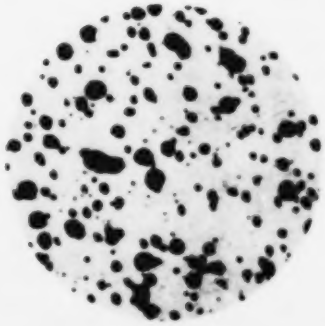
Spray pattern of 650067 tip @ 275 kPa.



Spray pattern 8002 LP tip @ 100 kPa.



Spray pattern of TK.75 tip @ 280 kPa.



Spray pattern of RD-1 Raindrop nozzle @ 210 kPa.

Calibration

Sprayer calibration is a two stage procedure which should be done in the yard before the spraying season begins. Before calibrating make sure that all nozzles, screens and filters are clean, and that the pressure gauge is giving an accurate reading of boom pressure.

Procedure:

1. Check each nozzle to ensure that its output is the same as the others.

With the sprayer operating at the desired pressure, collect the output from each nozzle for 30 seconds, using an accurate measuring cup.

Suitable calibration cups are available from agricultural offices and weed supervisors.

Record the output from each nozzle and replace any nozzles that are more than 5 percent above or below the average, or have a visibly streaked or distorted pattern. If the outputs are more than 15% above the outputs when the nozzles were new, replace them.

2. Check the output of the entire sprayer to determine the correct forward speed.

The following method requires no calculations or distance measurement. It is also much more accurate than checking the output of only one or two nozzles.

- Fill the sprayer tank with water.
- Operate the sprayer at the desired pressure for 15 minutes.
- Measure the number of litres needed to refill the tank.
- Refer to table 12 for the correct speed in km/h.

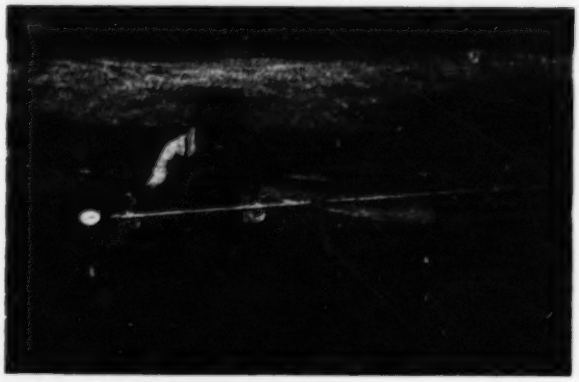
For other application volumes, number of nozzles, or nozzle spacings use this formula:

$$\textbf{Forward speed (km/h)} = \frac{\textbf{(litres per 15 min)} \times 4000}{\textbf{(Number of nozzles)} \times \textbf{(nozzle spacing in cm)} \times \textbf{(desired application volume in L/ha)}}$$

Example: *A sprayer with 31 nozzles at 75 cm spacings uses 450 litres in 15 minutes. Desired application volume is 100 L/ha.*

$$\text{Correct forward speed} = \frac{450 \times 4000}{31 \times 75 \times 100} = 7.7 \text{ km/h}$$

Tractor tachometers are often inaccurate so the actual forward speed of the tractor should be checked in the field. This can be done by using the Speed Chart (Table 13).



Checking nozzle outputs.

Table 12. Calibration Chart

Litres per 15 Minutes To Apply		Number of Nozzles — 50 cm Spacings									
50 L/ha	100 L/ha	24	26	27	30	33	34	35	36	37	39
		kilometres per hour									
100	200	6.7	6.2	5.9	5.3	4.8	—	—	—	—	—
110	220	7.3	6.8	6.5	5.9	5.3	5.2	5.0	4.9	—	—
120	240	8.0	7.4	7.1	6.4	5.8	5.6	5.5	5.3	5.2	4.9
130	260	8.7	8.0	7.7	6.9	6.3	6.1	5.9	5.8	5.6	5.3
140	280	9.3	8.6	8.3	7.5	6.8	6.6	6.4	6.2	6.1	5.7
150	300	10.0	9.2	8.9	8.0	7.3	7.1	6.9	6.7	6.5	6.2
160	320	10.7	9.8	9.5	8.5	7.7	7.5	7.3	7.1	6.9	6.6
170	340	11.3	10.5	10.1	9.1	8.2	8.0	7.8	7.6	7.4	7.0
180	360	12.0	11.1	10.7	9.6	8.7	8.5	8.2	8.0	7.8	7.4
190	380	—	11.7	11.3	10.1	9.2	8.9	8.7	8.4	8.2	7.8
200	400	—	—	11.9	10.7	9.7	9.4	9.2	8.9	8.6	8.2
210	420	—	—	—	11.2	10.2	9.9	9.6	9.3	9.1	8.6
220	440	—	—	—	11.7	10.7	10.4	10.1	9.8	9.5	9.0
230	460	—	—	—	—	11.1	10.8	10.5	10.2	9.9	9.4
240	480	—	—	—	—	11.6	11.3	11.0	10.7	10.4	9.8
250	500	—	—	—	—	—	11.8	11.4	11.1	10.8	10.3
260	520	—	—	—	—	—	—	11.9	11.6	11.2	10.7
270	540	—	—	—	—	—	—	—	12.0	11.7	11.1
280	560	—	—	—	—	—	—	—	—	—	11.5
290	580	—	—	—	—	—	—	—	—	—	11.9

Litres per 15 Minutes To Apply		Number of Nozzles — 50 cm Spacings									
50 L/ha	100 L/ha	41	42	48	49	53	55	61	63	67	81
		kilometres per hour									
130	260	5.1	5.0	—	—	—	—	—	—	—	—
140	280	5.5	5.3	—	—	—	—	—	—	—	—
150	300	5.9	5.7	5.0	—	—	—	—	—	—	—
160	320	6.2	6.1	5.3	5.2	—	—	—	—	—	—
170	340	6.6	6.5	5.7	5.5	5.1	—	—	—	—	—
180	360	7.0	6.9	6.0	5.9	5.4	5.2	—	—	—	—
190	380	7.4	7.2	6.3	6.2	5.7	5.5	5.0	—	—	—
200	400	7.8	7.6	6.7	6.5	6.0	5.8	5.2	5.1	—	—
210	420	8.2	8.0	7.0	6.9	6.3	6.1	5.5	5.3	5.0	—
220	440	8.6	8.4	7.3	7.2	6.6	6.4	5.8	5.6	5.3	—
230	460	9.0	8.8	7.7	7.5	6.9	6.7	6.0	5.8	5.5	—
240	480	9.4	9.1	8.0	7.9	7.2	7.0	6.3	6.1	5.7	—
250	500	9.8	9.5	8.3	8.2	7.5	7.3	6.5	6.3	6.0	4.9
260	520	10.1	9.9	8.7	8.5	7.9	7.6	6.8	6.6	6.2	5.1
270	540	10.5	10.3	9.0	8.8	8.2	7.9	7.1	6.9	6.4	5.3
280	560	10.9	10.7	9.3	9.1	8.5	8.1	7.3	7.1	6.7	5.5
290	580	11.3	11.0	9.7	9.5	8.8	8.4	7.6	7.4	6.9	5.7
300	600	11.7	11.4	10.0	9.8	9.1	8.7	7.9	7.6	7.2	5.9
310	620	—	11.8	10.3	10.1	9.4	9.0	8.1	7.9	7.4	6.1
320	640	—	—	10.7	10.5	9.7	9.3	8.4	8.1	7.6	6.3
330	660	—	—	11.0	10.8	10.0	9.6	8.6	8.4	7.9	6.5
340	680	—	—	11.3	11.1	10.3	9.9	8.9	8.6	8.1	6.7
350	700	—	—	11.7	11.4	10.6	10.2	9.2	8.9	8.4	6.9
360	720	—	—	12.0	11.8	10.9	10.5	9.4	9.1	8.6	7.1
370	740	—	—	—	—	11.2	10.8	9.7	9.4	8.8	7.3
380	760	—	—	—	—	11.5	11.1	10.0	9.7	9.1	7.5
390	780	—	—	—	—	11.8	11.3	10.2	9.9	9.3	7.7
400	800	—	—	—	—	—	11.6	10.5	10.2	9.6	7.9
410	820	—	—	—	—	—	11.9	10.7	10.4	9.8	8.1
420	840	—	—	—	—	—	—	11.0	10.7	10.0	8.3
430	860	—	—	—	—	—	—	11.3	10.9	10.3	8.5
440	880	—	—	—	—	—	—	11.5	11.2	10.5	8.7
450	900	—	—	—	—	—	—	11.8	11.4	10.7	8.9
460	920	—	—	—	—	—	—	—	11.7	11.0	9.1
470	940	—	—	—	—	—	—	—	11.9	11.2	9.3
480	960	—	—	—	—	—	—	—	—	11.5	9.5
490	980	—	—	—	—	—	—	—	—	11.7	9.7
500	1000	—	—	—	—	—	—	—	—	11.9	9.9

Note: *The table is correct only for a nozzle spacing of 50 cm. For 100 cm spacings, multiply the number of nozzles on the sprayer by 2 before entering the table.*

Example: *Sprayer with 48 nozzles at 50 cm spacings. Desired application volume — 100 L/ha. After 15 minutes of spraying 500 litres are required to refill sprayer tank. Follow the 100 L/ha column down to 500. Go across to the column for 48 nozzles. Read off the correct speed — 8.3 km/h.*

Table 13. Speed Chart

km/h	Time to Travel 800 m (min:s)	km/h	Time to Travel 800 m (min:s)
5.0	9:36	8.6	5:35
5.2	9:14	8.8	5:27
5.4	8:52	9.0	5:20
5.6	8:34	9.2	5:13
5.8	8:17	9.4	5:07
6.0	8:00	9.6	5:00
6.2	7:44	9.8	4:54
6.4	7:30	10.0	4:48
6.6	7:16	10.2	4:43
6.8	7:04	10.4	4:38
7.0	6:52	10.6	4:32
7.2	6:40	10.8	4:27
7.4	6:29	11.0	4:22
7.6	6:19	11.2	4:17
7.8	6:09	11.4	4:13
8.0	6:00	11.6	4:08
8.2	5:51	11.8	4:04
8.4	5:43	12.0	4:00

An alternate procedure is:

1. Fill the sprayer tank with water.
2. Using a field of known length, spray up and down the field at the desired forward speed and pressure setting.
3. Measure the amount of water required to refill the tank.
4. Calculate the application volume using the following formula:

$$\textbf{Litres per hectare} = \frac{\textbf{litres used x 10,000}}{\textbf{width of sprayer (m) x distance travelled (m)}}$$

Example: *Distance travelled = 1600 m*
Litres used = 300 L, Width of sprayer = 18 m

$$\text{Application volume} = \frac{300 \times 10{,}000}{18 \times 1600} = 104 \text{ L/ha}$$

5. If the actual application volume is different than what is desired, change the forward speed or nozzle size and begin again at (1).

Field Adjustments and Operation

Nozzle heights should be adjusted in the field according to the information given in Table 4. The measurements should be taken in the field with the tank about 1/2 full to allow for wheel sinkage.

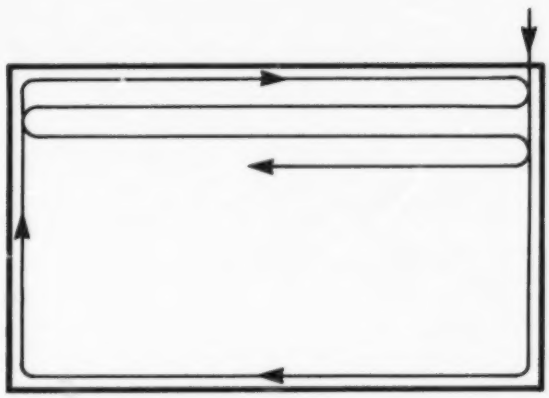
Standard 80° or 110° flat spray nozzles should be operated at 200 to 300 kPa unless higher pressures are recommended by the herbicide manufacturer.

End nozzles should be used **only** for roadsides, fence rows and ditches, and only when winds are very light. The spray patterns from end nozzles are very non uniform and are also much more likely to create damaging spray drift due to the direction at which the spray leaves the nozzle.

A constant forward speed is essential for uniform spraying. The tractor tachometer should be watched closely to ensure that a constant engine speed is maintained. Due to differences in tire sizes and wheel slippage the indicated speed on the tractor tachometer is not reliable. A time trial (see Table 13) should be used to determine the actual forward speed, and the selected engine speed then maintained throughout the field. A speedometer mounted on a nondriving wheel may also be used to provide a more accurate indication of forward speed.

The tractor drawbar should be securely pinned, and the connection between the tractor and sprayer should be firm to keep the booms moving forward at a constant rate. A sturdy ball and socket hitch is ideal.

A suggested field coverage pattern is given below. The booms should be shut off for the turns at the headlands. This eliminates overlapping and uneven application rates at the corners.



Suggested field coverage pattern.

Cleaning and Storage of Sprayers

At the end of each spraying day, the tank should be thoroughly rinsed out with clean water under high pressure. Clean water should then be sprayed out through the nozzles, and after a few minutes the plugs at the ends of the booms should be removed to allow complete flushing of the boom. Adding some liquid detergent to the rinsing water will help to reduce any build-ups of foreign material on pressure regulators and check valves. Flushing with clean water should follow the use of a detergent solution. All nozzles, screens and filters should be checked and cleaned if necessary. Use compressed air to clean nozzles.

A more complete cleaning of the sprayer is needed when changing from one chemical to another. Even a small amount of chemical left in the sprayer can create serious damage to subsequently sprayed crops. If an ester of 2,4-D, MCPA or 2,4,5-T has been used proceed as follows:

1. Drain the entire sprayer completely and flush it out with clean water.
2. Rinse the tank and the rest of the sprayer with kerosene or diesel fuel, using a mop or scrub brush to wash the inside of the tank.
3. Rinse the sprayer with a solution of 1 kg detergent per 100 L of water to remove the oil.
4. Continue with steps 5 to 10.

To remove amine and salt formulations:

5. Rinse the sprayer with clean water.

6. Drain the sprayer completely and then partially fill the tank with clean water and add one part household ammonia for every 100 parts of water in the tank.
7. Circulate the solution within the sprayer, and spray some out through the nozzles.
8. Wash the inside of the tank using a mop or scrub brush.
9. Allow the solution to remain in the tank for 8 to 24 hours.
10. Recirculate the solution and rinse the sprayer thoroughly with clean water. As a final check before using the sprayer on 2,4-D sensitive crops, spray some of the final rinse solution onto bean, tomato, potato or squash plants. If no herbicide symptoms show within three days, the sprayer is safe to use.

Note: *Various products have specific cleaning instructions. These should be followed carefully to avoid subsequent crop damage.*

Caution: *Never enter a tank that has had chemicals in it.*

When putting the sprayer into storage, use the following procedure:

1. Clean the sprayer thoroughly. Drain it completely, especially the filters, pressure regulator, selector valve and gauges.
2. Remove the pump and follow the manufacturer's storage recommendations.
3. Seal off any openings to prevent entry of dirt, debris or rodents.
4. Make a list of all parts needing replacement and order them well in advance of the next spraying season.
5. Store the sprayer in a place where it will not be damaged by other equipment or livestock. Polyethylene tanks should be stored under cover to prevent deterioration by sunlight.

Liquid Fertilizers

Many field sprayers are not suitable for spraying liquid fertilizers. Corrosion resistance is one of the main problems in handling fertilizers. Tanks of stainless steel, mild steel, polyethylene or fibreglass are suitable for nitrogen and ammonium phosphate. Aluminum is suitable for nitrogen but not ammonium phosphate. Galvanized steel is not suitable for use with liquid fertilizers.

Large nozzles are usually needed for the application volumes used with liquid fertilizers. Stainless steel nozzles are most common, although nylon or teflon may be used.

Fittings of stainless steel, nylon or other plastics are suitable. Aluminum fittings may be used with straight nitrogen solutions, but not for ammonium phosphate. Brass, bronze, copper and galvanized metals should not be used with any fertilizers.

Nylon roller pumps may be used for pumping liquid fertilizers although the high application volumes used require pumps with high capacities. Ground driven piston pumps are often used for liquid fertilizer applicators. Centrifugal and turbine pumps are also suitable if constructed of fertilizer resistant materials.

Since liquid fertilizer is typically 20 to 40% heavier than water, the frame and wheels of the sprayer may be overloaded if the tank is filled with fertilizer. Check with the manufacturer for the maximum carrying capacity of the sprayer.

Metric Conversion

1 fl oz = 28.41 mL
1 fl oz/acre = 70.21 mL/ha
1 oz = 28.35 g
1 lb = 0.4536 kg
1 lb/acre = 1.121 kg/ha
1 inch = 2.54 cm
1 inch = 25.4 mm
1 lb/in^2 (psi) = 6.895 kPa
1 mile = 1.609 km
1 gal = 4.546 L
1 gal/acre = 11.23 L/ha
1 acre = 0.4047 ha
1 ft = 0.3048 m

1000 μm = 1 mm
10 mm = 1 cm
100 cm = 1 m
1000 m = 1 km

1000 mL = 1 L
1000 g = 1 kg
10 000 m^2 = 1 ha

Symbols

kilometre	km
metre	m
centimetre	cm
millimetre	mm
hectare	ha
kilopascal	kPa
litre	L
millilitre	mL
kilogram	kg
gram	g
micrometre	μm

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